smaller than the distance, gp, between that center and the surface of the upper shield. This is because, since the free layer is nearer to the lower shield than to the upper shield, it is more influenced by the magnetic field from the lower shield than from the upper shield, and, in addition, since the center through which sense current passes is shifted to the side of the nonmagnetic spacer 145, the free layer receives the magnetic field from the lower shield (this is generated by the lower shield as magnetized by sense current) in the direction opposite to the sense current magnetic field direction. With the sense current magnetic field being attenuated, a larger sense current may be applied to the device, whereby higher reproduction output and better BP are obtained, or that is, the asymmetry in the vertical direction of the reproduction wave form is reduced. Concretely, gp may fall between 35 and 80 nanometers and gf may fall between 25 and 50 nanometers with $gf < gp$. In that condition, the gap insulation could be kept, and the total reproduction gap length may fall between 60 ad 130 nanometers to realize an extremely narrow gap.

The film constitution of the magnetoresistance effect device of the invention can be identified in various analyzing methods.

Fig. 53 is a graph of the data of nano-EDX analysis of the cross section of a magnetic head which incorporates the

magnetoresistance effect device of the invention. For example, samples for cross section TEM (transmission electron microscopy) are prepared, and subjected to nano-EDX with a beam of about 1 nanometer in diameter being applied to the cross section of each sample, whereby the materials constituting the magnetoresistance effect device and the film thicknesses can be identified. Considering the measurement limit and the influence of interfacial diffusion in thermal treatment, the film constitution could be almost reproduced. In particular, as will be understood from Fig. 53, the interface between the free layer and the spacer Cu and the interface between the free layer and the nonmagnetic high-conductivity layer of Cu are relatively sharp, and the film thicknesses are easy to identify.

Regarding the definition of the film thickness, the half-value width of the peak for the material of the main element constituting the film of which the thickness is intended to be determined is defined as the thickness of the film. For example, the spacer Cu and the nonmagnetic high-conductivity layer (underlayer) of Cu give a sharp peak, their thicknesses are easy to determine. Based on these, therefore, the thickness of the free layer is defined as the region sandwiched between the upper and lower Cu layers. In the example of Fig. 53, the thickness of the spacer Cu is determined to be 2.4 nanometers, and that of the nonmagnetic

high-conductivity layer to be 2 nanometers. The total thickness of the free layer as sandwiched between the two Cu layers could be 4.1 nanometers. The thus-calculated thickness of the free layer is to nearly reproduce the intended free layer thickness of 3.7 nanometers. Through the analyses noted above, the film constitution of the spin valve film of the invention could be identified, and the thicknesses of the spacer layer, the nonmagnetic high-conductivity layer and the free layer (even though it is extremely thin) could be measured relatively accurately.

The invention can be carried out in the manner of the embodiments mentioned hereinabove, and has the following advantages.

According to the first embodiment of the invention, provided is a spin valve film with good bias point control, high MR and high ΔRs, which, however, could not be realized by merely thinning the free layer in conventional spin valve films. The margin for process latitude in producing the spin valve film of the invention is broad. Thus, the spin valve film of the invention is favorable to the coming new-generation devices in the art.

According to the second to sixth embodiments of the invention, provided are a magnetoresistance effect device (MR device), especially a giant magnetoresistance effect device (GMR device), in which the pinned magnetic layer is kept stable